1964

Strength changes of collegiate wrestlers during and following their competitive season

John Francis Polo

The University of Montana

STRENGTH CHANGES OF COLLEGIATE WRESTLERS DURING

AND FOLLOWING THEIR COMPETITIVE SEASON

by

JOHN FRANCIS POLO JR.

B.S. University of Oregon, 1963

Presented in partial fulfillment of the requirements

for the degree of

Master of Science

MONTANA STATE UNIVERSITY

1964

Approved by:

Chairman, Board of Examiners

Dean, Graduate School

AUG 14 1964

Date

ACKNOWLEDGEMENTS

The author wishes to express his gratitude and appreciation to Mr. Wayne E. Sinning for his guidance and counseling during the completion of this study.

Also, the author wishes to express his appreciation to the 1964 Montana State University Varsity Wrestling Team who served as subjects for this study.

J.F.P.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Table of Contents cont'd.

CHAPTER I

THE PROBLEM AND RELATED LITERATURE

The Problem

Statement of the Problem

The purpose of this investigation was to study the strength of varsity wrestlers throughout their competitive season. Specifically, the strengths of muscle groups which control certain shoulder, arm and hand movements were measured at selected time intervals to determine whether or not any strength changes might occur during the course of the competitive season.

Significance of the Study

Hassman[1] found a significant increase in the elbow flexor strength of both the right and left arms in wrestlers after a six week cessation of training following the competitive season. This finding leads one to ask the question, "What happens to the strength of wrestlers during their competitive season?" If there is a definite pattern of strength changes during the course of a season, it would be an advantage for wrestlers and their coaches to know about it since they could then better plan their training programs

---

[1]Ralph P. Hassman, "Changes in the Physical Status of Varsity and Freshman Wrestlers of the University of Oregon Following a Six Week Cessation of Organized Team Practices and Competition," D.Ed. Thesis, University of Oregon, June, 1961.

in order to maintain an optimum strength level. Also, an understanding of any changes that might occur would be of help when planning other investigations on how to maintain, build, or reach the maximum strength at the desired time in the competitive wrestling season.

Basic Assumption

The assumption was made that any strength changes that might occur would be due to the participation of the subjects in the wrestling conditioning and training program.

Limitations

The following limitations were made in regard to the number of subjects and muscle groups tested:

1. Strength tests were administered only to selected muscle groups which control movements about the hand, arm and shoulder joints.
2. The subjects who were tested were limited to the Montana State University 1964 Varsity Wrestling team. Those wrestlers who acquired shoulder or elbow injuries at any time prior to the investigation, or during the investigation, were dropped from the sample group.

Definitions

The following terms are defined as they were used in this study.

<u>Competitive Season</u>. - The competitive season was

defined as that period of time between the first and the last dual wrestling meets, not including any post-season tournaments or championships. For the 1963-64 wrestling season it was January 4th through February 29th.

Grip. - The grip is formed through a movement of the fingers into a flexed position commonly referred to as a fist.

Elbow Flexion. - Flexion at the elbow occurs when the forearm is moved in a direction that diminishes the anterior angle at the elbow.

Elbow Extension. - Extension at the elbow occurs when the forearm is moved in a direction that increases the anterior angle at the elbow.

Shoulder Flexion. - Flexion at the shoulder occurs when the subject, in a supine lying position, attempts to move the upper arm from a position alongside the body to a vertical position.

Shoulder Extension. - Extension at the shoulder occurs when a subject, in a supine lying position with his upper arm flexed at the shoulder to a vertical position, attempts to return his upper arm to a position alongside the body.

Shoulder Horizontal Flexion. - Horizontal flexion at the shoulder occurs when the upper arm is moved across the chest from a position of 90 degrees shoulder flexion.

Shoulder Inward Rotation. - This occurs when the anterior aspect of the extremity moves in a medial direction around a longitudinal axis running through the extremity.

Shoulder Outward Rotation. - This occurs when the anterior aspect of the extremity moves in a lateral direction around a longitudinal axis running through the extremity.

Review of Related Literature

Many studies have been completed on the neuromuscular, cardiovascular and respiratory responses by wrestlers, but only a few have been done on their muscular strength. In those studies in which strength was measured, it was usually done so as a secondary aspect of the main problem.

Rasch[2] studied the muscular strength of non-athletes, collegiate wrestlers, AAU wrestlers and Japanese wrestlers. The four strength tests given were the right grip, the left grip, the back lift, and the leg lift. From the raw scores, he computed a Total Proportional Strength Index (TPS), which was the sum of the four strength tests divided by the subject's body weight. No significant changes were found between the mean scores of a non-athlete group, which was a college physical education class, and a college wrestling squad before and after a pre-season training period. Championship-level wrestlers were significantly stronger than non-wrestlers, but not significantly stronger than the college squad.

---

[2]J. Rasch, William R. Pierson, Eugene O'Connell and M. Briggs Hunt, "Effects of Training for Amateur Wrestling on Total Proportional Strength Scores," Research Quarterly, 32:201-207, May, 1961.

Hassman,[3] investigated the changes in the physical status of 27 college wrestlers six weeks after organized competition. As a part of this study, he measured the elbow flexor strength of both the right and left arms. He found that there was a significant increase in the elbow flexor strength during this period.

Gillum[4] administered the Rogers' Physical Fitness Test (PFI) to members of the Ohio State freshman and varsity wrestling squads on Fridays at approximately "Weigh-in" time and again on Mondays after the wrestlers had regained their normal body weight. The mean PFI for the 11 men who reduced weight during each week of the experiment was higher on Friday than on Monday. Gillum concluded that weight reduction did not affect strength and that the wrestlers who reduced weight were stronger pound for pound than those remaining at one weight.

Byram[5] studied the effects of weight reduction on the

---

[3]Ralph P. Hassman, "Changes in the Physical Status of Varsity and Freshman Wrestlers of the University of Oregon Following a Six Week Cessation of Organized Team Practices and Competition," D.Ed. Thesis, University of Oregon, June, 1961.

[4]Olden Curtice Gillum, "The Effects of Weight Reduction on the Body Strength of Wrestlers," Masters Thesis, Ohio State University, 1940.

[5]Howard Byram, "The Effects of Weight Reduction on Strength," Masters Thesis, State University of Iowa, 1953.

strength and muscular endurance of 14 wrestlers at the State University of Iowa. Strength tests, strength-endurance tests, and a circulatory-respiratory test were administered once each week for five consecutive weeks. A dynamometer was used to measure the maximum strength load of flexion and extension of the forearm, lower leg and trunk. The muscular endurance was measured through a repetitive movement of the body segment using a weight load of two-thirds the maximum pull in the dynamometer test. Circulatory-respiratory endurance was measured by a modified Carlson Fatigue Test. It was concluded that weight reduction up to 18.8 percent of the body weight had no detrimental effect on the strength, the muscular endurance, or the circulatory-respiratory endurance of the college wrestlers.

Nichols[6] selected five factors he felt were important for the physical efficiency of wrestlers. They were balance, reaction time, strength, power, and endurance. Balance was measured by the Stepping Stone Test, reaction time was measured by a chronoscope based on the principle of moving from under a falling object, strength was measured by Roger's PFI Test, power by the "chalk jump" test, and endurance by a variation of the Harvard Step Test. He measured each factor five times within a ten week period. He concluded that

---

[6] Harold J. Nichols, "Effects of Rapid Weight Loss on Selected Physiologic Responses of Wrestlers," Ph.D Dissertation, University of Michigan, 1956.

weight loss within normal conditions and under current practices did not materially affect the strength of the wrestlers, slow their reaction time, affect their ability to maintain balance, adversely affect their endurance, or hinder their ability to develop power.

Tuttle[7] investigated the effects of weight loss by dehydration and withholding of food on the physiological responses of wrestlers. As a sub-problem of this study he measured the strength of each wrestler's right grip, left grip, chest pull, chest push, back raise and leg raise. It was concluded that there was no effect on either the strength or the muscular endurance of these wrestlers when they lost up to 5 percent of their body weight.

---

[7] W.W. Tuttle, "Effects of Weight Loss by Dehydration and Withholding of Food on the Physiologic Responses of Wrestlers," Research Quarterly, 14:158-166, May, 1943.

CHAPTER II

PROCEDURES OF THE STUDY

Subjects

Originally, the twenty-two wrestlers who came out for the 1964 Montana State University Varsity Wrestling Team were to be used as subjects for this study. The final sample consisted of 11 subjects (Table 1) who participated in wrestling throughout the season and in all testing periods. One subject was dropped from the sample because he participated in a weight training program which was not a part of normal team conditioning activities. The other subjects were dropped from the sample due to shoulder or elbow injuries to their dominant arm, academic inelegibility, or failure to return to school for the Winter Quarter.

At the time of the first testing period, the subjects had been participating in a conditioning program of not less than three weeks. Their practice activities during the competitive season consisted of routine wrestling team activities such as wrestling bouts, rope skipping, rope climbing, running, chinning, sit-ups, push-ups, and trunk bending exercises.

Choice of Equipment for Strength Measurement

The cable tensiometer was selected as the instrument for taking strength measurements. This instrument has been shown to have more accuracy than others designed for this purpose. Also, Clarke[1] has developed a series of standardized strength tests for use with this instrument.

TABLE I

SUBJECTS' WEIGHT DISTRIBUTION AMONG THE VARIOUS INTERCOLLEGIATE COMPETITIVE DIVISIONS

Subject	Normal* Weight	Competitive** Weight
L.B.	126	115
R.S.	132	123
A.V.	147	130
R.K.	146	137
R.P.	152	137
H.C.	157	147
L.D.	150	147
K.J.	164	157
R.T.	170	167
D.R.	204	191-Hvy.
D.H.	206	191-Hvy.

*Normal Weight: The normal weight of the individual wrestlers was that weight taken at the post-season testing period, six weeks following the competitive season and team workouts.

**Competitive weight: The competitive weight is that collegiate weight division that particular wrestler competed in during the season.

The relative merit of this device was shown by Clarke,[2] who found that the cable tensiometer was a better instrument for the measurement of strength than the Wakin-Porter strain gage, the spring scale, or the Newman myometer. Sixty-four

---

[1]H. Harrison Clarke and David H. Clarke, Developmental and Adapted Physical Education (Englewood Cliffs, N. J.: Prentice Hall, Inc., 1963), pp. 88-90.

[2]H. Harrison Clarke, "Comparison of Instruments for Recording Muscle Strength," Research Quarterly, 25:398-411, December, 1954.

male students at Springfield College were tested with the four instruments on strength tests of finger flexion, wrist dorsal flexion, shoulder outward rotation, neck extension, knee extension and ankle plantar flexion. This series of tests provided for weak, medium and strong movements so that the effectiveness of the instruments for testing various levels of muscular extension could be checked. The cable tensiometer was shown to be the most consistent of the four measuring devices. The objectivity coefficients (Correlation coefficient between a test and a retest) for the instrument were between .90 and .96. These were equal to or higher than the coefficients for the other instruments in all but the tests for finger flexion and for neck extension. The cable tensiometer was also found to be the most stable and generally useful of the four instruments and was free of most of the faults of the other devices. The strain gauge had a satisfactory degree of precision, but it was extremely sensitive to slight tension and changes in room temperature. Both the spring scale and the Newman myometer had deficiencies which limited their usefulness for strength testing.

Choice of Muscle Groups for Testing

Only those cable tension strength tests which measured the strength of the major movements at the shoulder, elbow and wrist joints were used in this study. The testing was confined to those movements due to the importance of upper body strength in wrestling. McCloy[3] has noted that arm strength represents not only the strength of the arms themselves, but also the strength of the pectoral muscles, the serratus anterior, the latissimus dorsi, and the deltoid. Hence, arm strength is not only the strength of the arms themselves, but also the strength of muscles that swing the arm.

Equipment and Apparatus

All test measurements were taken according to Clarke's[4] directions with the equipment he prescribed. This equipment is described in the following paragraphs.

The cable tensiometer. - The cable tensiometer (Figure 1) measures strength by measuring the tension on a cable due to a force exerted by the subject.

Chain and snap pulling assembly. - A short piece (12 to 18 inches) of one-sixteenth inch flexible cable was attached to a link chain approximately three feet long. A safety hook was fastened to the cable and connected the cable to the regulation strap D-ring. The cable tensiometer was placed on this cable in order to record the force exerted by the subject.

---

[3] C.H. McCloy, "The Apparent Importance of Arm Strength in Athletics," *Research Quarterly*, 5:3-11, March, 1934.

[4] H. Harrison Clarke, *A Manual Cable-Tension Strength Tests*, Springfield College, Published by Stuart Murphy, 1953. pp. 2-6.

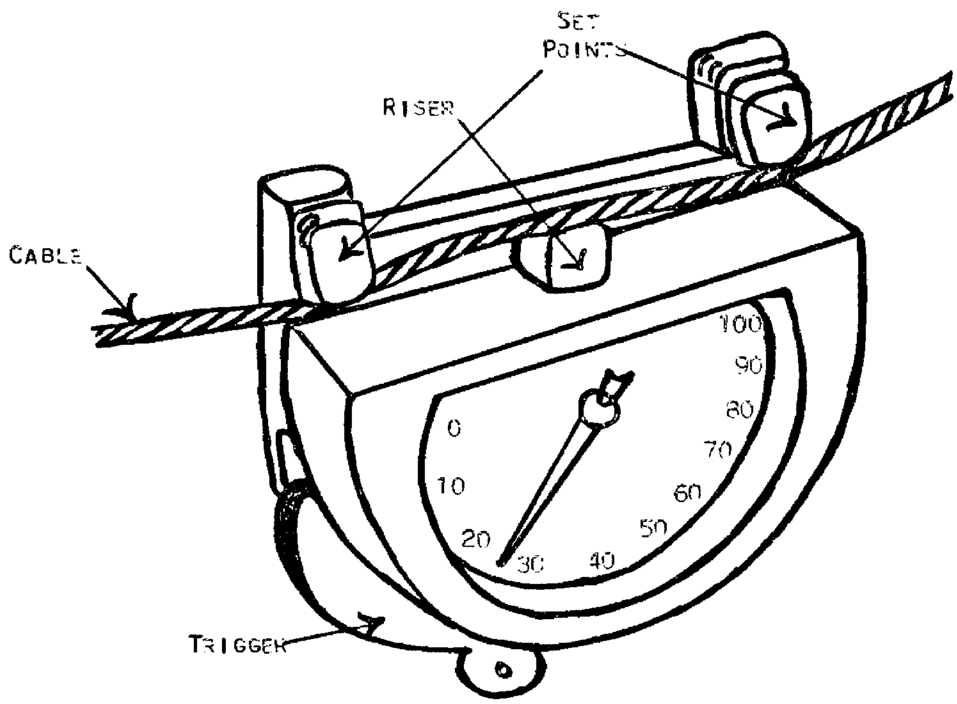


Figure 1. Cable Tensiometer. The cable tensiometer measures force exerted against a cable which has strung under the riser and over set points located on each side of the riser. This displacement was recorded on a scale. The displacement score was then converted into pounds through the use of a conversion chart which was set up prior to giving the tests by calibrating the tensiometer reading against known resistance.

<u>Regulation strap</u>. - The subject was attached to the pulling assembly by the regulation strap. This strap was constructed from a two inch-strip of parachute webbing which was looped and stitched firmly on a D-ring. In use, it was wrapped around the subject's limb and the D-ring snapped to the pulling assembly.

<u>Testing tables</u>. - Two tensiometer testing tables, approximately six feet six inches long, two feet nine inches wide, and two feet six inches high were available. These tables were designed to enable the subjects to lie in the proper position for each test.

<u>Wall hooks</u>. - Four open-eye screw hooks were secured

into a two inch by six inch by four foot board bolted to the wall to provide resistance against a subject's pull.

Table hooks. - In addition to the wall hooks, four open-eye screw hooks were placed on the testing table for tests of shoulder flexion, elbow flexion and elbow extension strength. Hooks for the elbow flexion and elbow extension strength tests were attached to a board placed across one end of the testing table approximately four inches from the floor and extending ten inches beyond both sides of the table. The hooks for the shoulder flexion test were attached to a board placed across the bottom of the table, approximately two feet from one end of the table at a right angle to its length.

Goniometer. - A goniometer was used to measure the joint angle at which force was to be applied by the subjects. This instrument was a plexiglass protractor with a fixed arm attached to its base line, and an adjustable arm attached to the mid-point of the base line. The angle was measured by moving the adjustable arm in relation to the fixed arm.

Grip Dynamometer. - The grip dynamometer was made up of a cable tensiometer and a frame to hold the tensiometer in place on a cable. The subject exerted force on its handle, and in this way a measurement of the grip strength could be taken.

Methods of Giving Tests

All test measurements were taken according to

Clarke's[5] directions with the equipment he prescribed. The methods used in each test are discribed in the following paragraphs.

<u>Grip</u>. - While in a standing position, the subject grasped the grip dynamoter in his dominant hand. His other hand was held away from the body or any supporting objects. The subject would then grip against the cable as hard as he could. Subjects were constantly encouraged by the tester.

<u>Elbow Flexion</u>. - The subject was placed in a supine lying position with his hips and knees flexed and his feet resting on the table. His free hand was placed on his chest. The subject's upper arm on the side being tested was adducted to a position alongside the body and resting on the supporting surface. His elbow was placed in 115 degrees of flexion and his forearm in a position halfway between pronation and supination. The strap was then placed around the forearm midway between the wrist and elbow joints and attached to the pulling assembly.

The assistant to the tester placed his hands on the table to the lateral side of the elbow to prevent raising or abduction of the elbow. The tester, while holding the tensiometer in place, would instruct the subject to pull exclusively with the forearm, not raising his head, his shoulders, or his hips.

<u>Elbow Extension</u>. - The subject was placed in the same

---

[5]Clarke, <u>Ibid</u>., pp. 16-20.

position as for the elbow flexion test except his elbow was placed in 40 degrees of flexion and his forearm held in a position halfway between pronation and supination. The regulation strap was placed around the forearm midway between the wrist and elbow joints.

The assistant to the tester placed his right hand on the subject's shoulder applying pressure to prevent him from lifting the shoulder from the table. The assistant's left hand was placed on the table to the lateral side of the subject's elbow to prevent abduction of the elbow. The subject was instructed to pull exclusively with the forearm, not raising his head, his shoulders, or his hips.

<u>Shoulder Flexion</u>. - The subject was placed in a supine lying position with his hips and knees flexed and his feet resting on the table. His free hand was placed on his chest. The subject's upper arm on the side being tested was adducted at the shoulder to a position alongside the body and his elbow flexed to 90 degrees. The strap was placed around the upper arm midway between the shoulder and the elbow joints.

The assistant to the tester placed both hands on the subject's shoulder applying pressure to prevent the shoulder from leaving the table. The tester, holding the tensiometer in place, placed his other hand on the subject's elbow preventing abduction of the elbow. The subject was instructed to keep his head, his shoulders, and his hips on the table while applying force and to flex the upper arm at the shoulder attempting to touch the ceiling with his hand.

Shoulder Extension. - The subject was placed in the same position as for the shoulder flexion test except that his upper arm on the side being tested was adducted to the body flexed to a position of 90 degrees. His elbow was flexed with the wrist held in a prone position. The strap was placed around the humerus midway between the shoulder and the elbow joints.

The assistant to the tester placed one hand on the subject's chest to prevent elevation of the shoulder. The subject was instructed to attempt to pull his upper arm down to his side, not raising his head, his shoulders, or his hips.

Shoulder Horizontal Flexion. - The subject was placed in a supine lying position with his hips and knees flexed and his feet resting on the table. His free hand was placed on his chest. The subject's upper arm on the side being tested was flexed at the shoulder to 90 degrees, his elbow was placed to 90 degrees of flexion and his upper arm rotated inward until the forearm was placed directly across the body in a position halfway between pronation and supination. The strap was placed around the upper arm midway between the shoulder and the elbow joints.

The assistant to the tester placed one hand on the table next to the subject's waist, and the other hand on the subject's wrist to assist in keeping the forearm horizontal and the upper arm vertical The subject was instructed to pull against the cable assembly and attempt to touch the opposite wall with his hand, not raising his head, his shoulders, or his hips during the test.

Shoulder Outward Rotation. - The subject was placed in a supine lying position with his hips and knees flexed and his feet resting on the table. The subject's upper arm on the side being tested was adducted to a position alongside the body and resting on the supporting surface. His elbow was placed in 90 degrees of flexion with the forearm placed in a position halfway between pronation and supination.

The strap was placed around the forearm at the distal end of the ulnar and radial bones. This was a deviation from Clarke's procedures in that he placed the strap at the midpoint between the wrist and the elbow joints. It was found in this study that two individuals with barrel type chests would need their upper arm elevated as much as three inches to prevent interference with the free action of the pulling assembly. The other end of the pulling assembly was attached to the wall hook on the side opposite to that being tested.

The assistant to the tester placed one hand on the table on the lateral side of the subject's elbow to prevent adduction of the elbow. The subject was instructed to attempt to touch the side wall with his hand, not raising his head, his shoulders, or his hips.

Shoulder Inward Rotation. - The subject was placed in the same position as for the shoulder outward rotation except that the upper arm on the side being tested was adducted to a position alongside the body. His elbow was placed in 90 degrees of flexion, and his forearm placed in a position half-way between pronation and supination. The strap was placed around the forearm midway between the wrist and the elbow joints.

The assistant to the tester placed his hand on the table to the lateral side of the subject's elbow to prevent abduction of the elbow during the test. The subject was instructed to keep his head, his shoulders, and his hips on the table during the test as he attempted to bring his hand across his chest.

Training of Testers

The testers were trained in the cable tensiometer testing methods for testing the strength of the eight selected muscle groups. Following a familiarization period, testers practiced by testing and retesting subjects until a high correlation coefficient between the test and retest was obtained. This correlation coefficient is referred to as the objectivity coefficient. For practice, subjects were taken from a physical education service class and tested and retested until the objectivity coefficients obtained by the testers were equal to or better than limits described by Clarke.[6] His objectivity coefficients ranged from .93 to .97 while the tester's ranged from .96 to .99.

---

[6] Clarke, Ibid.

Experimental Procedures

The subjects were tested by appointment on Monday or Tuesday of each week in which tests were given. Four tests were given at two week intervals during the season. One test was given six weeks after the termination of organized team practice and competition.

When a subject arrived at the laboratory, he stripped himself of his clothes and weighed himself. He then re-dressed with the exception of any long sleeve shirts or sweaters. The subject then completed the personal information section on the test record card while the tester briefed him as to what was expected of him during the testing.

If two qualified testers were available, tests would be given simultaneously at two tables. When two tables were being used, no more than six subjects were tested in one hour. If only one table were being used, a maximum of three subjects were tested in one hour.

Each subject was given a rest period of no less than one minute nor more than three minutes between each trial for each movement. During this rest period, it was possible to test one or two other subjects on the same test item, and then return to the first subject for his next trial.

The test was administered in the following manner:

1. The grip was administered to all subjects prior to any other test. This order was followed to prevent a fatiguing of that muscle group by the

unconscious gripping or clinching of the fist during other tests.

2. If two testers were present, the subjects were divided into two groups, and a group assigned to each table. If only one tester was present, only one group was formed and all tests were completed at one table before testing began at the second table.

Regardless of the number of testers or subjects, each test was always given on the same testing table. The tests of shoulder extension, shoulder inward rotation, shoulder horizontal flexion, and shoulder outward rotation were given at one table while the tests of shoulder flexion, elbow extension and elbow flexion were given at the other.

Interpretation of Scores

Each test was given three times. The extreme score for each test period was omitted on the assumption that some factor other than the strength of the muscle group caused the greater variation of scores to occur. The remaining two scores were converted into pounds through the use of a conversion chart, and the mean value of these two scores calculated and then recorded as the strength of that muscle group for that particular testing period.

CHAPTER III

ANALYSIS AND DISCUSSION OF RESULTS

Method of Analysis

The data that was collected from the 11 subjects over the five testing periods was analyzed by the Walsh Test to determine whether the strength changes that occurred from test period to test period were significant. The Walsh Test was selected for this study because with it no assumptions of the normality of the sample population needs to be made. Since physical characteristics of the members of a wrestling team are influenced by the competitive weight classifications, a non-parametric technique was felt to be desirable.

Analysis of Results

The mean differences in pounds between strength scores on successive tests are shown for each muscle group for each test in Table II. The .05 level of confidence was the point at which the null hypothesis was rejected.

Seven of the eight muscle groups tested had a significant decrease in strength between Test I and Test II. These were the shoulder flexor, shoulder extensor, elbow flexor, elbow extensor and grip muscle groups. The shoulder horizontal flexors and inward rotators showed a significant increase for this same period. There was no change in the shoulder outward rotator strength.

At the time of Test III, the shoulder outward rotator, shoulder inward rotator, elbow flexor and grip muscle groups

TABLE II

WALSH TEST -- SIGNIFICANT CHANGES IN STRENGTH OF ALL EIGHT MUSCLE GROUPS

Muscle Group	Mean Strength Differences Between Test Periods							
	T.P. I-II		T.P. II-III		T.P. III-IV		T.P. IV-V	
	Diff. (Pounds)	Sig. Level	Diff. (Pounds)	Sig. Level	Diff. (Pounds)	Sig. Level	Diff. (Pounds)	Sig. Level
1. Shoulder Flexion	- 6.5*	.005	+ 1.5	.028	- 3.2	.028	+16.2	.005
2. Shoulder Extension	- 9.2	.005	+ 1.4	(not)	- 0.2	(not)	+27.4	.005
3. Shoulder Horiz. Flexion	+12.1	.005	+ 6.3	(not)	+ 3.1	.028	+35.8	.005
4. Shoulder Outward Rotation	- 3.0	(not)	- 4.2	.005	+ 5.7	.011	+ 1.5	.025
5. Shoulder Inward Rotation	+ 9.8	.011	- 2.5	.048	+ 6.2	.005	+12.2	.005
6. Elbow Flexion	- 7.4	.011	- 6.2	.028	+ 3.9	.028	+23.7	.005
7. Elbow Extension	-15.7	.005	+ 4.4	(not)	+ 8.7	.028	+ 2.5	.028
8. Grip	- 3.0	.011	- 1.8	.048	+ 2.4	.011	+11.9	.005

* (+ or -) indicates an increase or decrease between test periods.

showed a significant decrease in strength from that measured at the time of Test II. The shoulder flexors showed a significant increase for this same time interval while the shoulder extensor, shoulder horizontal flexor and elbow extensor muscle groups showed no change.

In Test IV all of the muscle groups but one showed a significant increase over that of Test III. The shoulder extensors showed no change in strength during this two week period.

Between Test IV and Test V there was the six week cessation of organized team practice and competition following the end of the wrestling season. At the end of this six week period (Test V), it was found that not only did all eight muscle groups show a significant strength increase, but also six of the eight muscle groups showed a better strength performance than they had in any of the other test periods. The other two muscle groups had mean strength scores that were within .1 pound of the mean of the highest performance for the other four test periods.

Figure 2 illustrates the trend of the strength changes of each muscle group from test to test. These trends are shown for each muscle group in Figures four through eleven in Appendix A. A general trend towards a decrease in strength during the first half of the season was followed by an increase in strength towards the end of the season. The greatest changes that occurred were during the six week post-season period following organized team practice and competition. Only the shoulder horizontal flexion group showed a

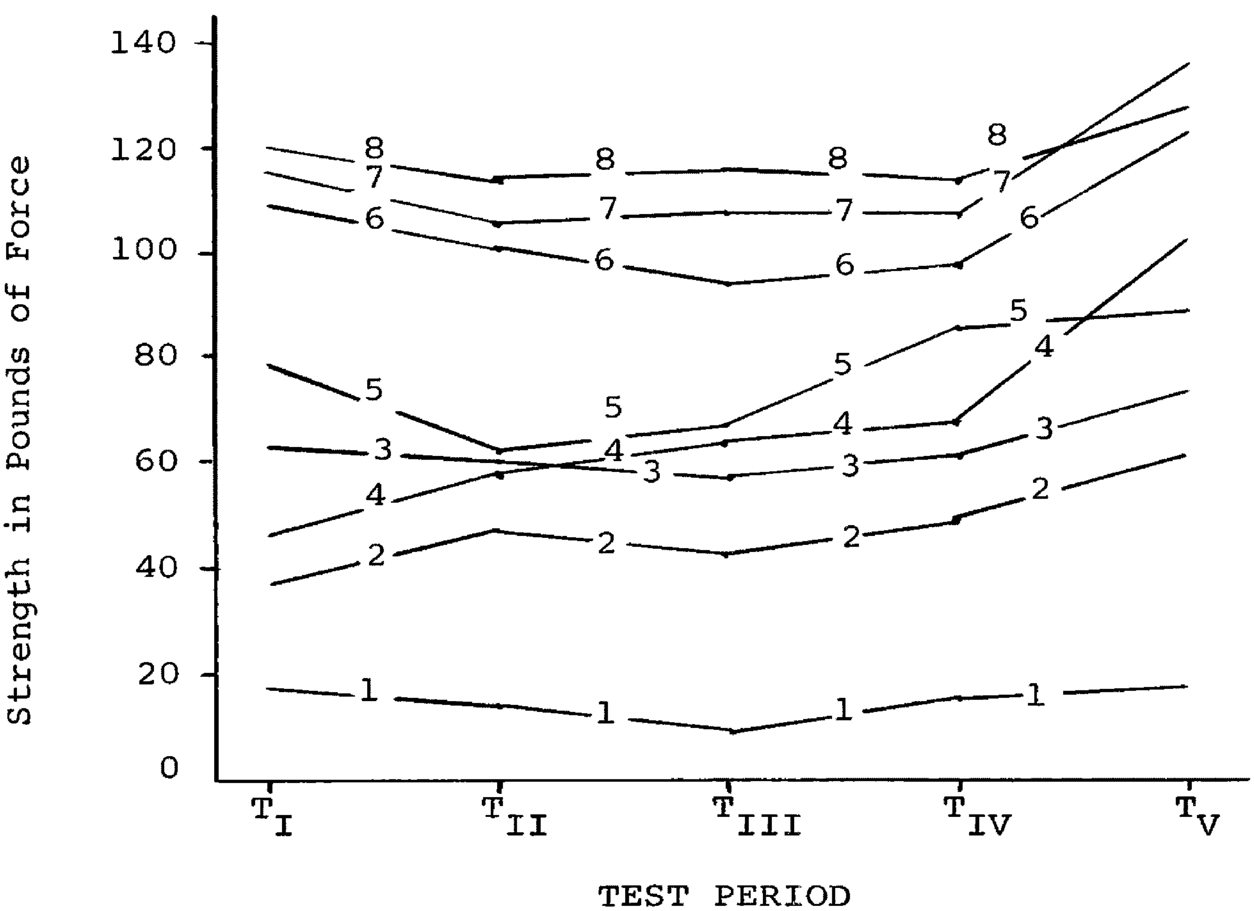


Figure 2. The mean strength score of each muscle group from test period to test period.

-1- Shoulder Outward Rotation
-2- Shoulder Inward Rotation
-3- Grip
-4- Shoulder Horizontal Flexion
-5- Elbow Extension
-6- Elbow Flexion
-7- Shoulder Extension
-8- Shoulder Flexion

consistent strength increase throughout the period of the study.

Discussion of Results

The finding of strength increases in the muscle groups after the cessation of training was in accord with that of Hassman.[1] He found a significant increase in the elbow flexor strength of both the right and left arms of varsity and freshman wrestlers at the University of Oregon, following a six week cessation of training after the competitive season. Clarke, Shay, and Mathews[2] found that under conditions of ergographic exercise to exhaustion, the strength of the elbow flexors continue to gain for four weeks after the end of a four week training period. These increases may be due to some phenomena associated with strength development, or merely the result of stopping the fatiguing activities of the conditioning program.

The time interval between Test III and Test IV covered the last two weeks of the competitive season. During the week prior to Test IV, the coach (author) felt that the wrestlers were exhibiting signs of fatigue and were not training with their usual enthusiasm. To counteract this, no organized

---

[1]Ralph P. Hassman, "Changes in the Physical Status of Varsity and Freshman Wrestlers of the University of Oregon Following a Six Week Cessation of Organized Team Practices and Competition," D.Ed. Thesis, University or Oregon, June, 1961.

[2]Clarke, Shay, and Mathews, "Strength and Endurance Effects of Exhaustive Exercise of the Elbow Flexor Muscles," Journal of Association of Physical and Mental Rehabilitation, 7 January-February, 1953.

team practice was held during that week in an attempt to change the regular routine of daily workouts. Each wrestler participated in an activity of his own choice. Some wrestlers chose to run and do calisthentics, others worked on wrestling holds and moves, while others participated in dual and team sports. A few concentrated on studies and worked-out only three days of that week. In their dual meet that weekend, the team recorded an 18-11 victory over a team they had tied only two weeks earlier. It was the opinion of the coach and team members that in this week's match all but one wrestler had wrestled his best match of the season up to that time.

This change in routine was accompanied by a reversal of the apparent downward trend of strength shown by the results from test periods I, II, and III. This would support the contention that the strength increase at this point and at the end of the season was due to the removal of the fatiguing factors, and support the idea that intermittent rest periods during the season would be of benefit for the maintenance of strength.

Despite this there was also evidence that this might have been due to some other factor. Figure 3 shows the strength patterns of subject D.J. who was dropped from the sample due to his participation in a physical education weight training class. With the exception of the shoulder outward rotation and the grip, this subject's strength scores showed a trend towards an increase in the strength of all muscle groups. Since

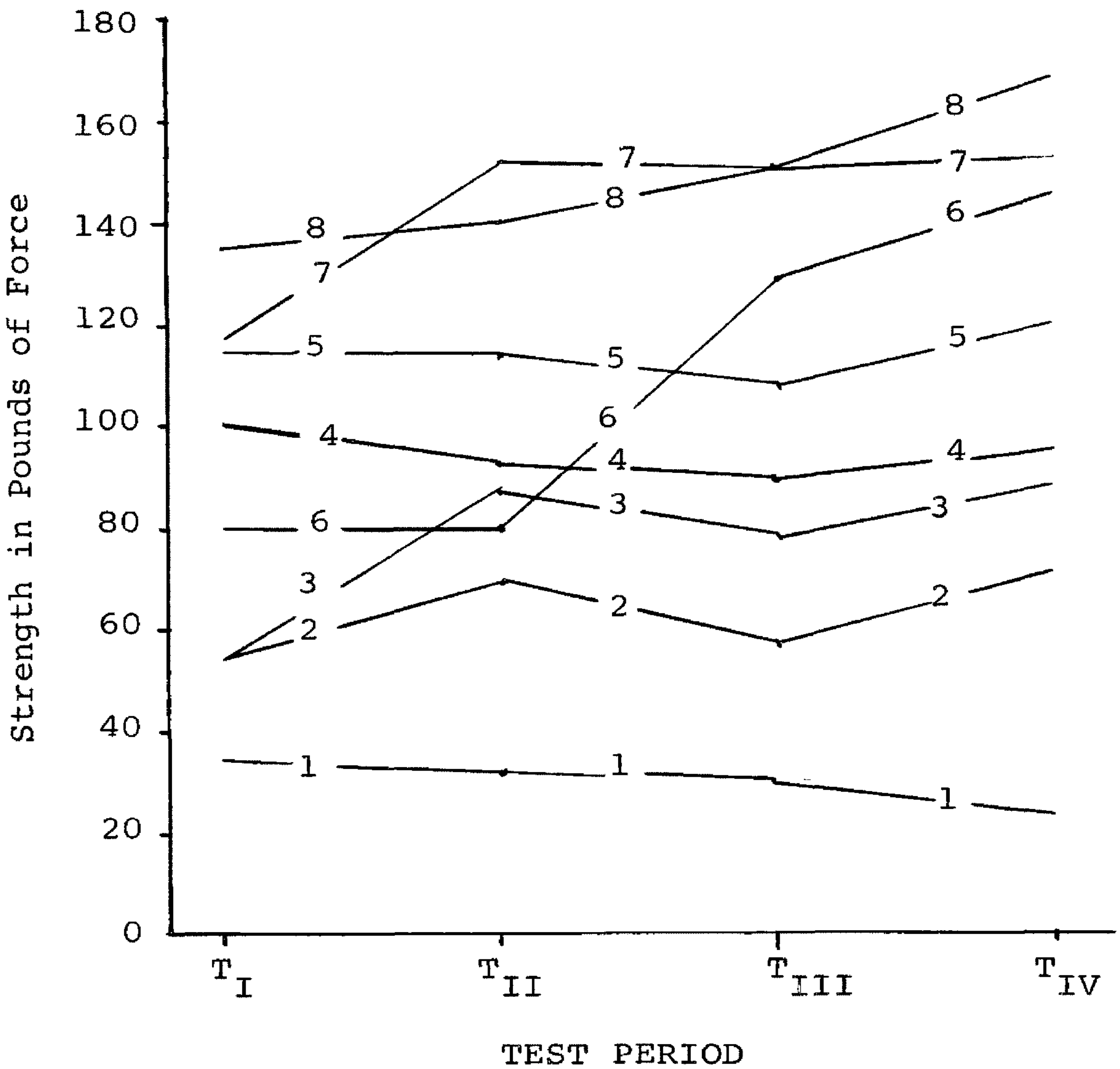


Figure 3. Individual strength scores of subject D.J. from test period to test period.

-1- Shoulder Outward Rotation
-2- Shoulder Inward Rotation
-3- Shoulder Horizontal Flexion
-4- Grip
-5- Elbow Flexion
-6- Elbow Extension
-7- Shoulder Flexion
-8- Shoulder Extension

this subject was simultaneously participating in two separate training programs, these increases could hardly be attributed to the cessation of fatiguing activities.

In the final analysis, the only conclusions that can be drawn here are that there were apparent general strength decreases as the season progressed, and these were followed by apparent general increases after one week of limited training two weeks prior to the end of the competitive season. There was also an apparent strength increase six weeks after the cessation of organized team practice and competition. Whether these changes were related to fatigue or some phenomena associated with strength development is a point for interesting discussion. The answer to this is beyond the scope of this study, but should provide a basis for interesting future investigations.

CHAPTER IV

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The purpose of this investigation was to study the strength of varsity wrestlers throughout the competitive season. Specifically, the strengths of muscle groups which control certain shoulder, arm and hand movements were measured at selected time intervals to determine whether or not any strength changes might have occurred during the course of the competitive season.

The cable tensiometer was selected as the instrument for taking strength measurements. Clarke[1] has developed a series of 38 standardized strength tests for use for this instrument. Eight of these tests were used in this study. The movements tested were: (1) shoulder flexion, (2) shoulder extension, (3) shoulder horizontal flexion, (4) shoulder outward rotation, (5) shoulder inward rotation, (6) elbow flexion, (7) elbow extension, and (8) grip.

Data were collected from 11 members of the 1964 Montana State University Varsity Wrestling Team by testing them four times during the competitive season, and once again six weeks after the end of the competitive season and organized team training.

---

[1]H. Harrison Clarke, A Manual Cable-Tension Strength Test, Springfield College, Published by Stuart Murphy, 1953.

Upon the completion of each testing period the raw tensiometer scores were converted into pounds through the use of a conversion table set up prior to the first testing period. The mean of the two closest scores were taken as the representative score for that muscle group for that particular testing period. The third score was omitted on the assumption that some factor other than the strength of the muscle group caused the greater variation to occur.

The strength changes were illustrated graphically, and the data were analyzed to determine whether significant strength changes had occurred between test periods. The Walsh Test was used to test a null hypothesis of no differences between strength scores from successive test periods.

It was found that:

1. Seven of the eight muscle groups had a significant decrease in strength between Test I and Test II. These were the shoulder flexor, shoulder extensor, elbow flexor, elbow extensor and grip muscle groups. The shoulder horizontal flexors and inward rotators showed a significant increase for this same period, while the shoulder outward rotators showed no change.
2. At the time of Test III, the shoulder outward rotator, shoulder inward rotator, elbow flexor and grip muscle groups had a significant decrease in strength from that measured at the time of Test II. The shoulder flexors showed a significant increase for this same test interval, while the shoulder

extensors, shoulder horizontal flexors and elbow extensors showed no change.

3. In Test IV, following a week of no organized team practice, all of the muscle groups but one showed a significant increase over that of Test III. The shoulder extensors showed no change in strength during this two week period.

4. Between Test IV and Test V there was the six week cessation of organized team practice and competition following the end of the wrestling season. At the end of this six week period (Test V) all eight muscle groups showed a significant strength increase. Six of the eight muscle groups showed their best strength performance for the entire study.

Conclusions

On the basis of the findings of this study the following conclusions were made:

1. In each of the eight muscle groups tested there were significant strength changes at some time during the course of the competitive season.

2. There was an apparent general decrease in the strength of the muscle groups tested in this study throughout the first eight weeks of the competitive season.

3. Following a one week "lay-off", during which the training routine was modified, a significant increase in strength occurred in seven of the eight muscle groups.

4. Following a six-week cessation of training and competition, all muscle groups showed a significant increase in strength. Seven of the eight muscle groups showed higher strength scores at this point than they had at any other test period.

Recommendations

In view of the findings and conclusions from this study, the following recommendations have been made.

1. Similar studies should be made in which more muscle groups in different areas of the body are tested. This would help determine whether the changes observed here are characteristic of the body as a whole or of only specific muscle groups.
2. A study should be made to determine the possibility of utilizing spaced rest periods to maintain strength throughout a lengthy training period.
3. A study should be made to determine the effects of weight training as part of the wrestlers' conditioning program during the season. It was observed in this study that the one wrestler who participated in a weight training program as well as in varsity wrestling showed apparent strength increases throughout the season. Such a pattern was shown by no other team member.

BIBLIOGRAPHY

BIBLIOGRAPHY

A. BOOKS

Clarke, H. Harrison, A Manual - Cable-Tension Strength Tests, Springfield College, Mass.: Stuart E. Murphy, Publisher, 1953. pp. 31.

Clarke, H. Harrison, and David H. Clarke, Developmental and Adapted Physical Education (Englewood Cliffs, N. J. Prentice Hall, Inc., 1963), pp. 364.

B. PERIODICALS

Clarke, H. Harrison, "Comparison of Instruments for Recording Muscle Strength," Research Quarterly, 25:398-411, December, 1954.

Clarke, Shay and Mathews, "Strength and Endurance Effects of Exhaustive Exercise of the Elbow Flexor Muscles," Journal of Association of Physical and Mental Rehabilitation 7 January-February, 1953.

Rasch, J., William R. Pierson, Eugene O'Connell and M. Briggs Hunt, "Effects of Training for Amateur Wrestling on Total Proportional Strength Scores," Research Quarterly, 32:201-207, May, 1961.

Tuttle, W.W., "Effects of Weight Loss by Dehydration and Withholding of Food on the Physiologic Responses of Wrestlers," Research Quarterly, 14:158-166, May, 1943.

C. UNPUBLISHED MATERIAL

Byram, Howard, "The Effects of Weight Reduction on Strength," Masters Thesis, State University of Iowa, 1953.

Gillum, Olden Curtice, "The Effects of Weight Reduction on the Body Strength of Wrestlers," Masters Thesis, Ohio State, 1940.

Hassman, Ralph P., "Changes in the Physical Status of Varsity and Freshman Wrestlers of the University of Oregon Following a Six Week Cessation of Organized Team Practices and Competition," D.Ed. Thesis, University of Oregon, June, 1961.

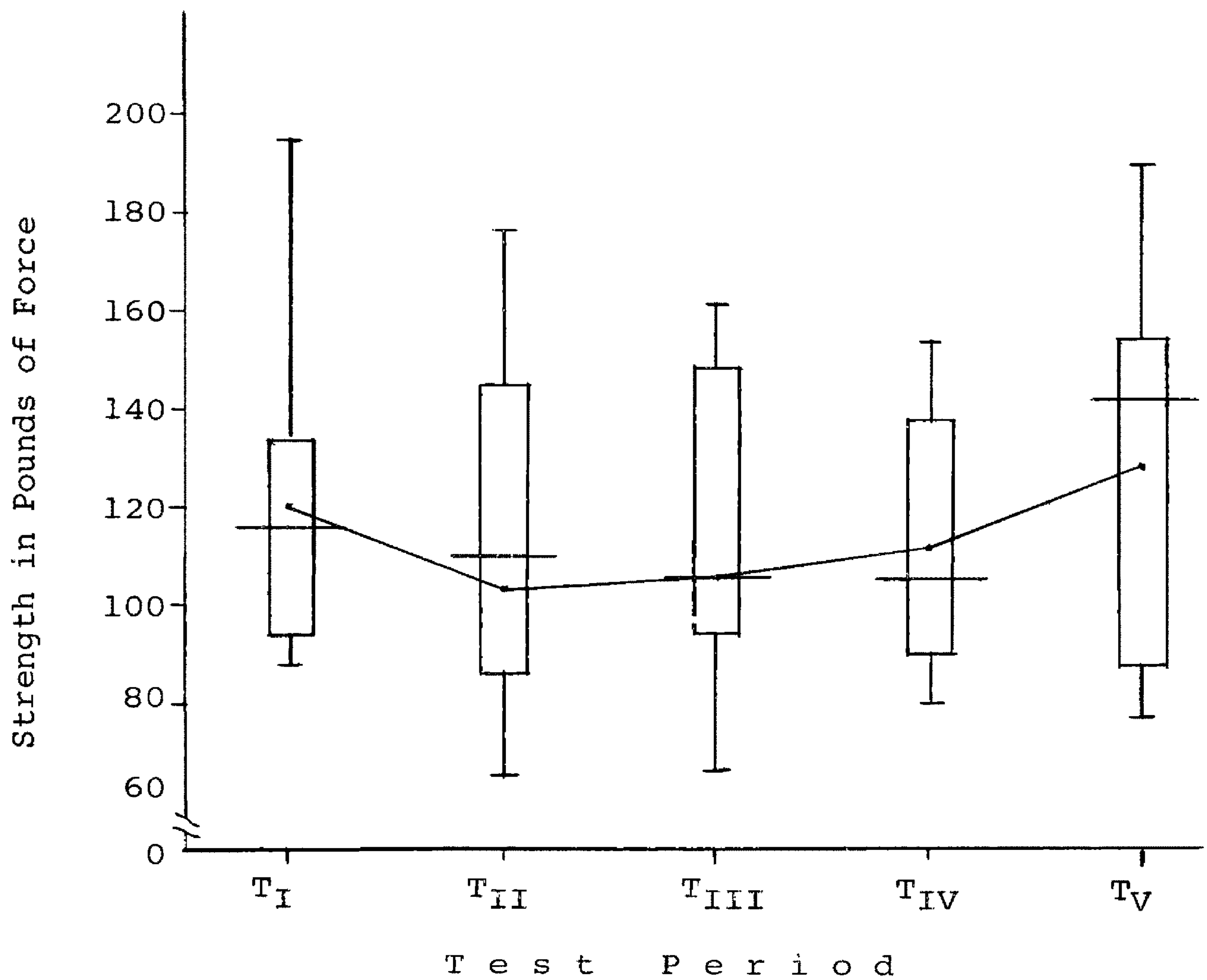
Nichols, Harold J. "Effects of Rapid Weight Loss on Selected Physiologic Responses of Wrestlers," Ph.D. Dissertation, University of Michigan, 1956.

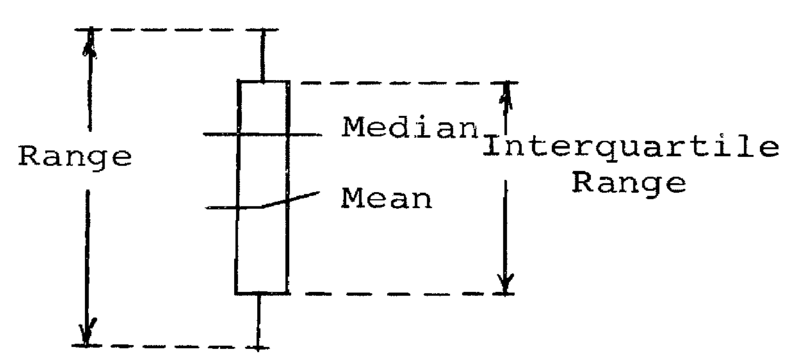
APPENDIX

APPENDIX A

Figure 4

SHOULDER FLEXION MEAN SCORES IN POUNDS OF THE 11 SUBJECTS FOR THE FIVE TEST PERIODS

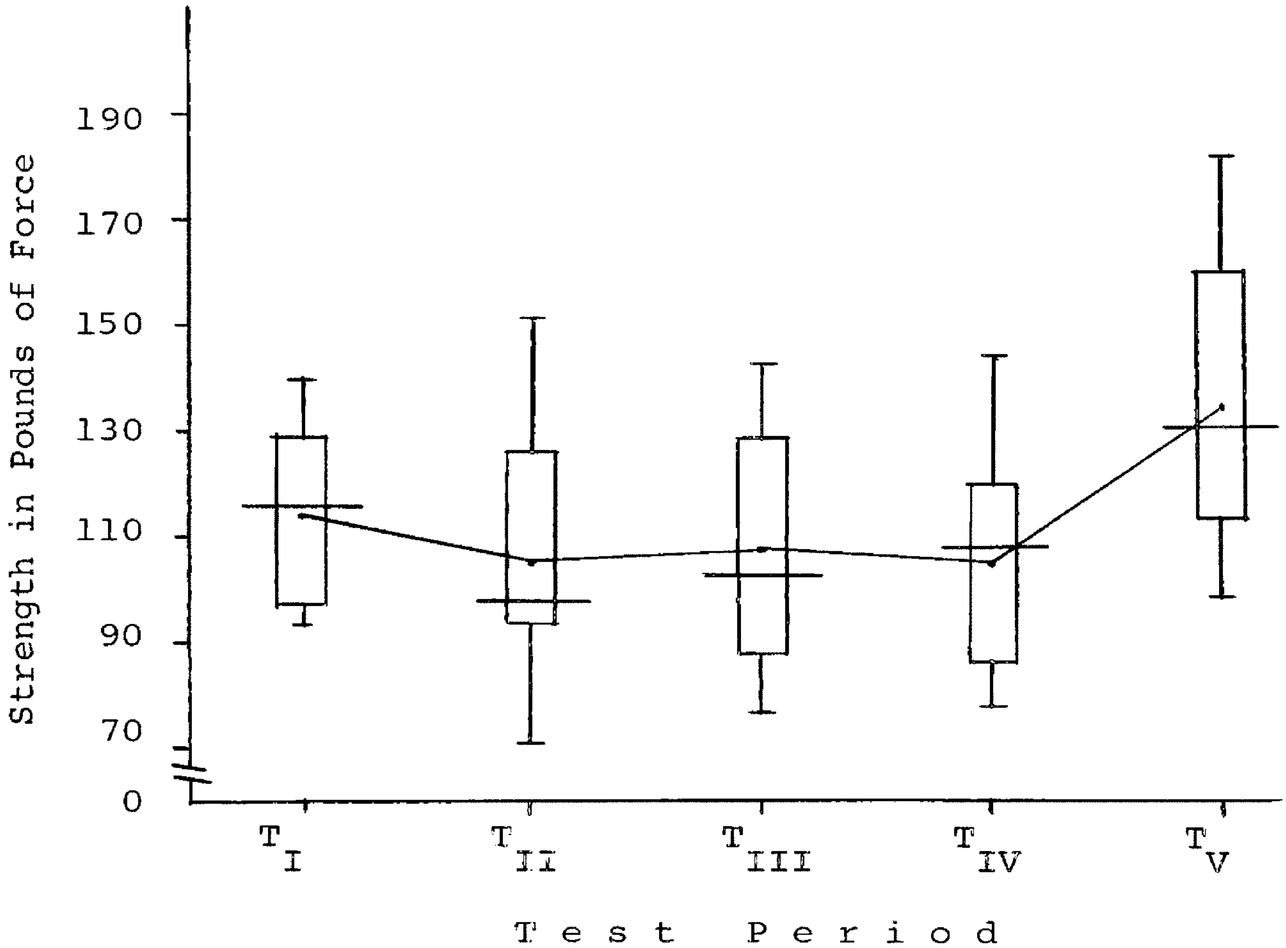


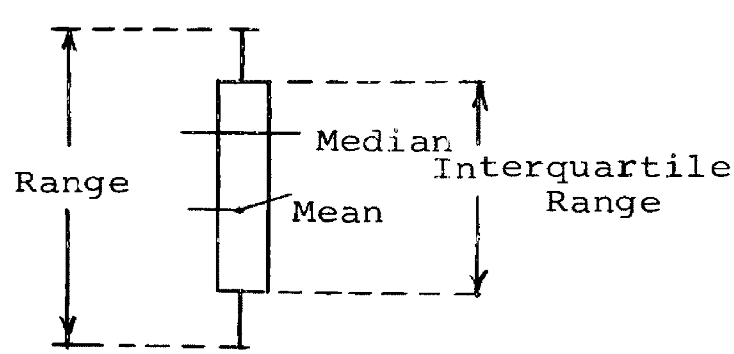


APPENDIX A (continued)

Figure 5

SHOULDER EXTENSION MEAN SCORES IN POUNDS OF THE 11 SUBJECTS FOR THE FIVE TEST PERIODS

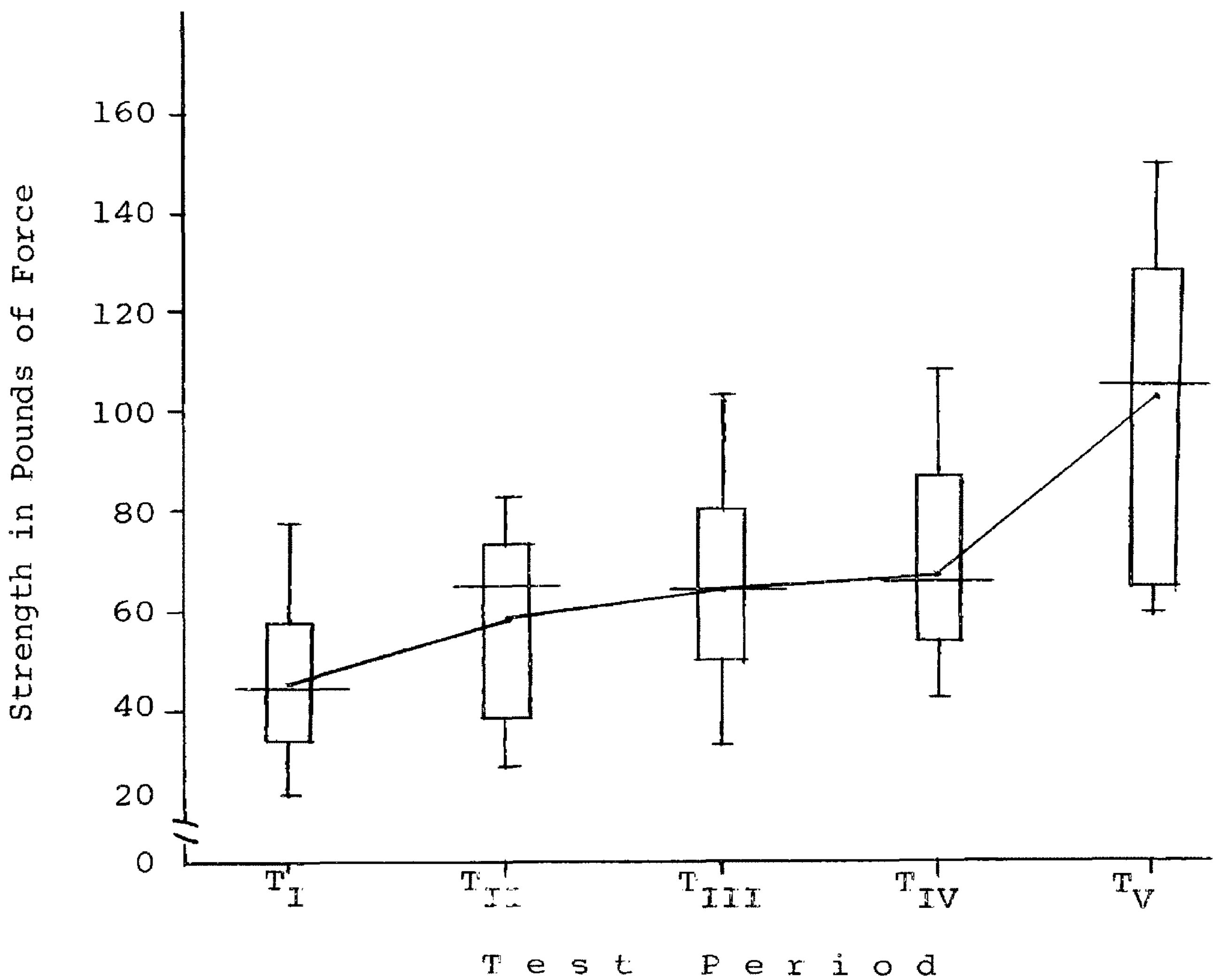


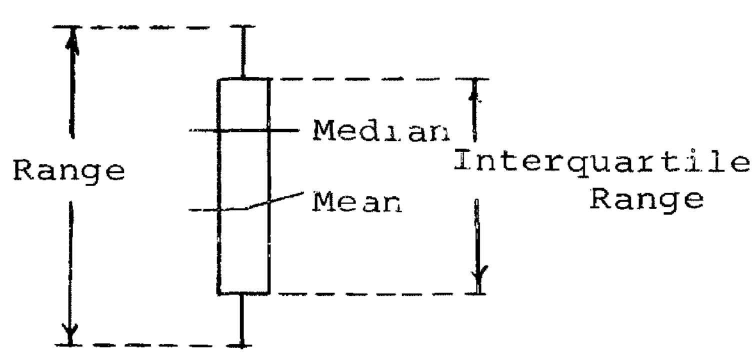


APPENDIX A (continued)

Figure 6

SHOULDER HORIZONTAL FLEXION MEAN SCORES IN POUNDS OF THE 11 SUBJECTS FOR THE FIVE TEST PERIODS

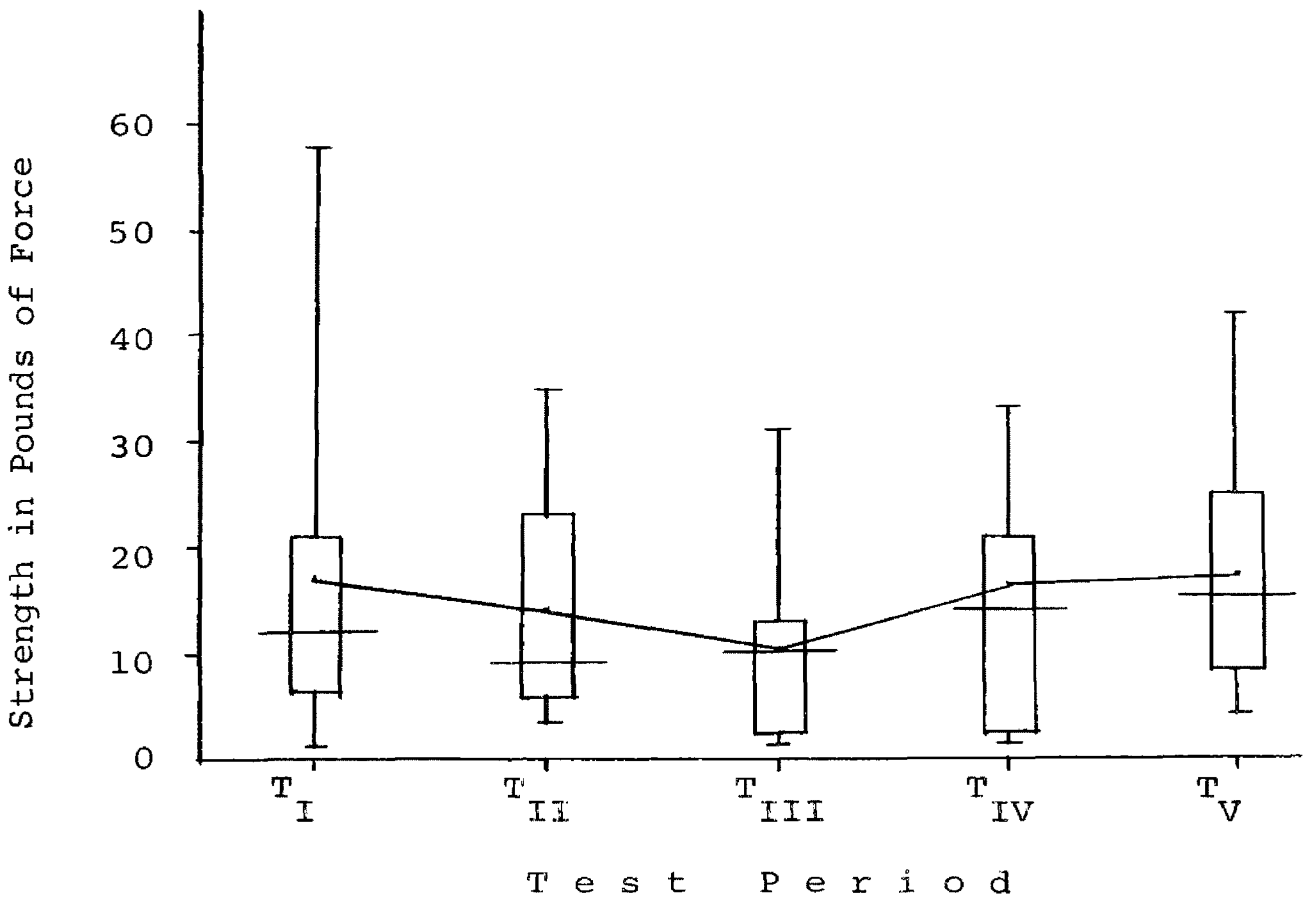


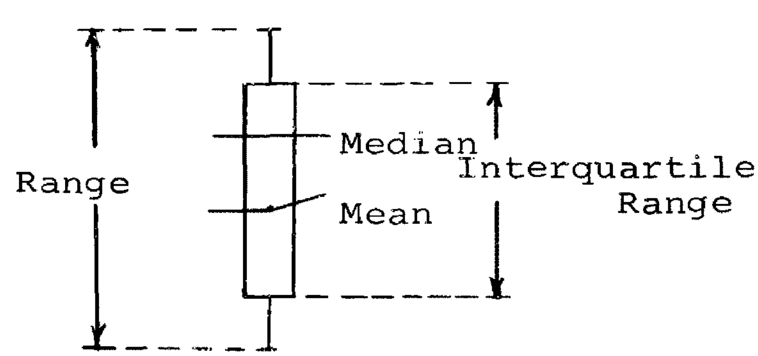


APPENDIX A (continued)

Figure 7

SHOULDER OUTWARD ROTATION MEAN SCORES IN POUNDS OF THE 11 SUBJECTS FOR THE FIVE TEST PERIODS

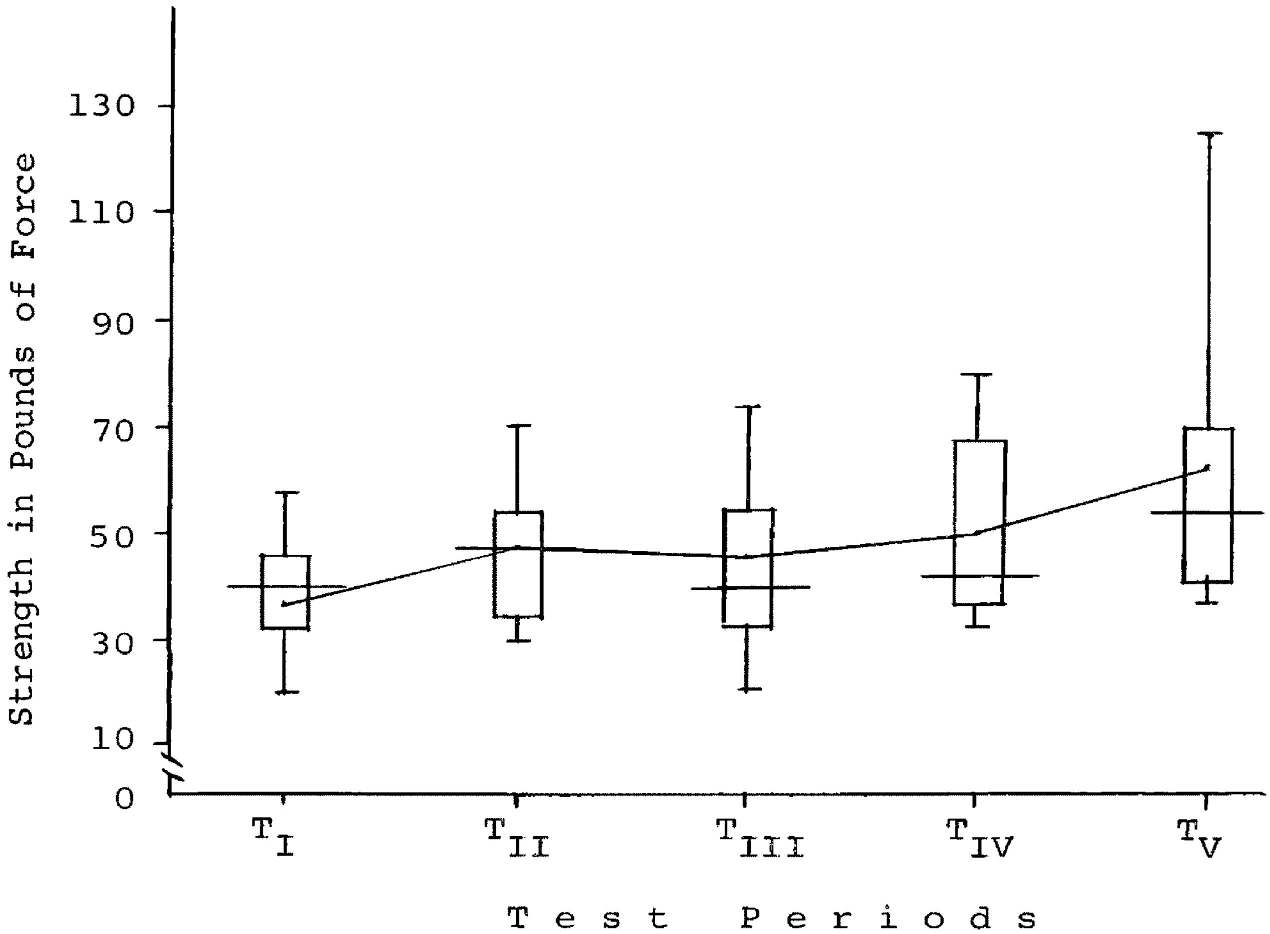


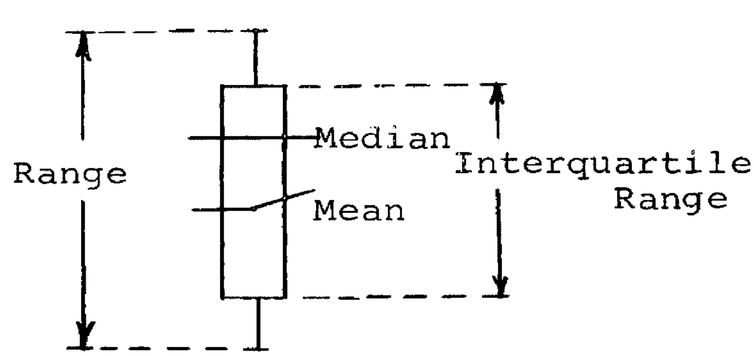


APPENDIX A (continued)

Figure 8

SHOULDER INWARD ROTATION MEAN SCORES IN POUNDS OF THE 11 SUBJECTS FOR THE FIVE TEST PERIODS

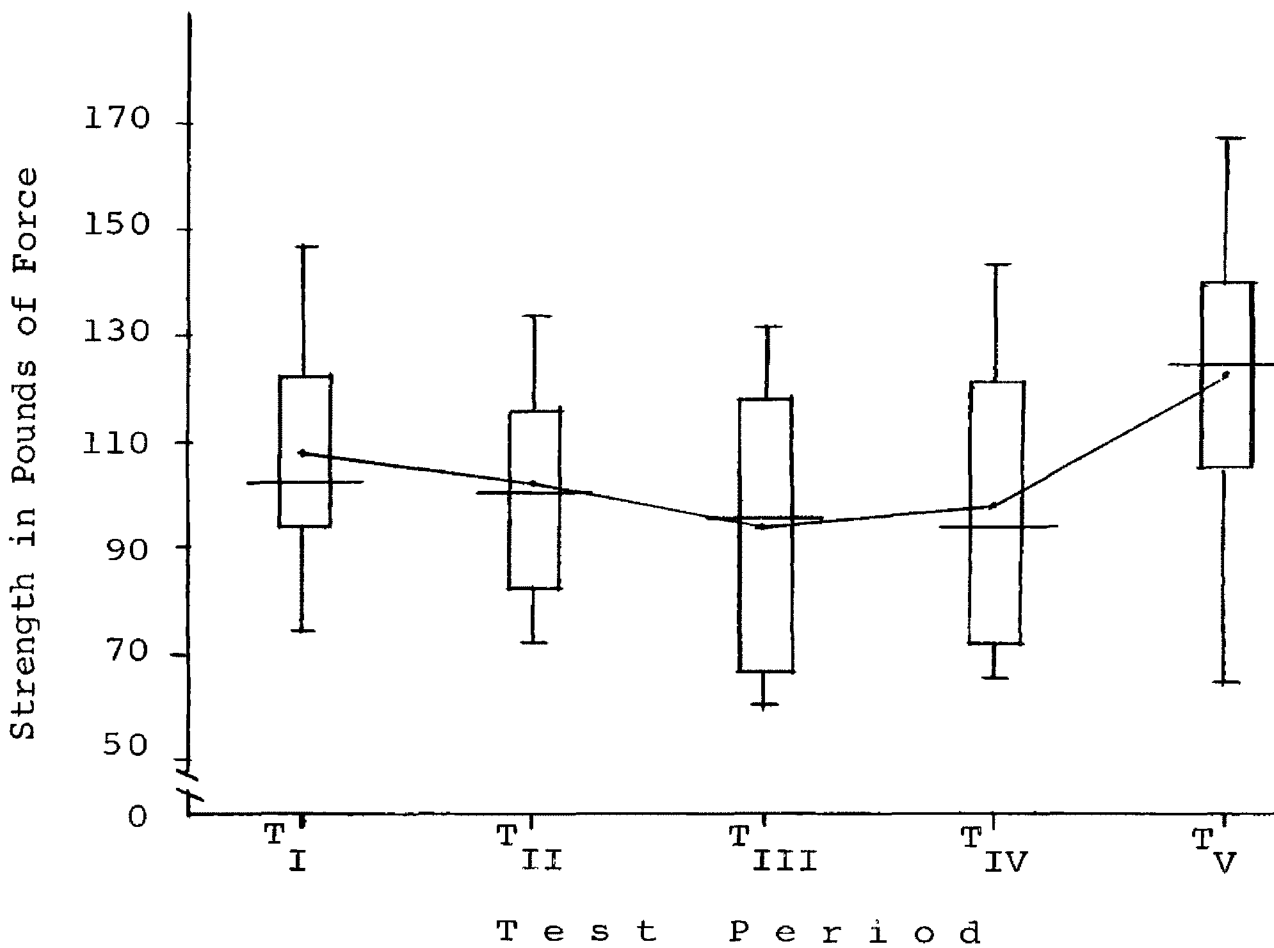


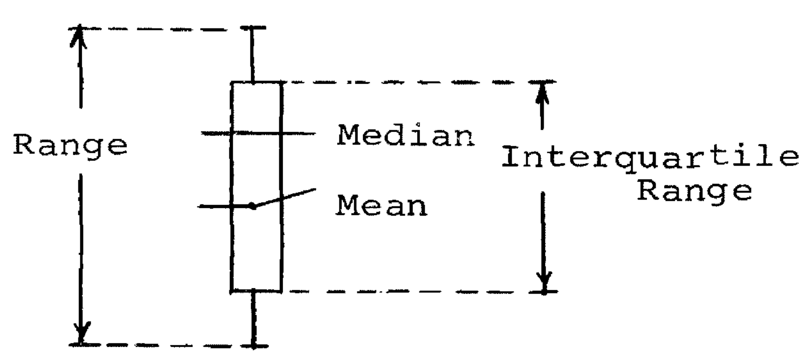


APPENDIX A (continued)

Figure 8

ELBOW FLEXION MEAN SCORES IN POUNDS OF THE 11 SUBJECTS FOR THE FIVE TEST PERIOD

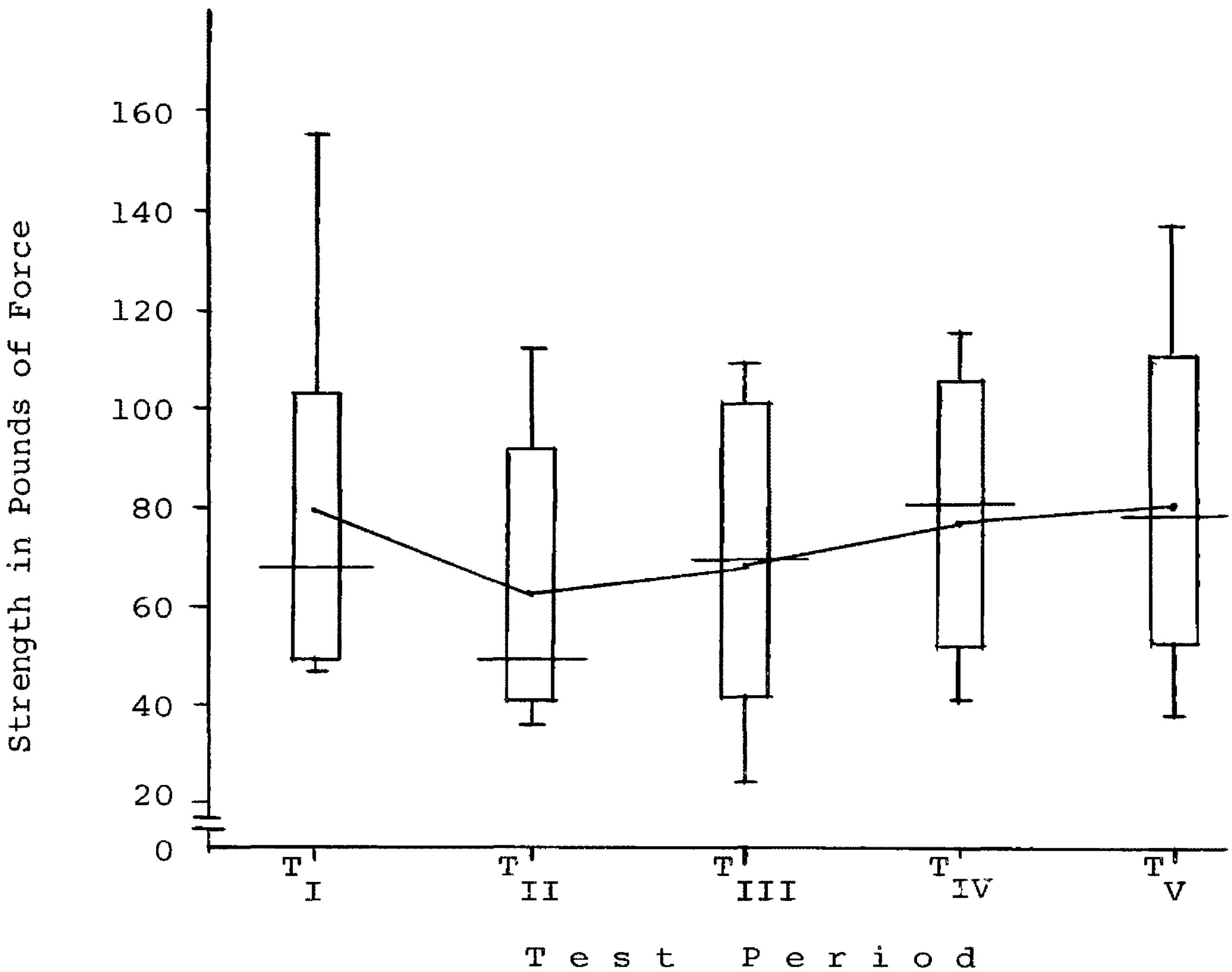


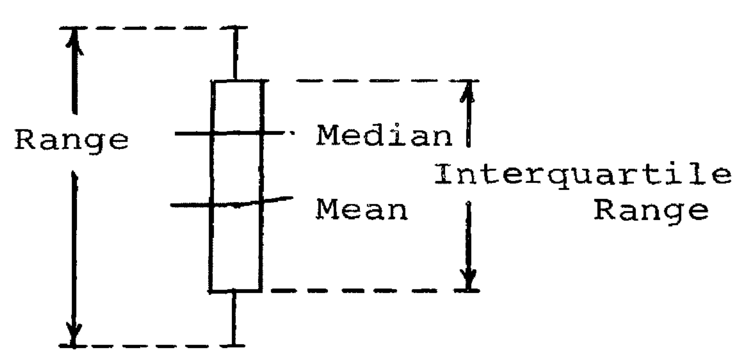


APPENDIX A (continued)

Figure 10

ELBOW EXTENSION MEAN SCORES IN POUNDS OF THE 11 SUBJECTS FOR THE FIVE TEST PERIODS





APPENDIX A (continued)

Figure 11

GRIP MEAN SCORES IN POUNDS OF THE 11 SUBJECTS FOR THE FIVE TEST PERIODS